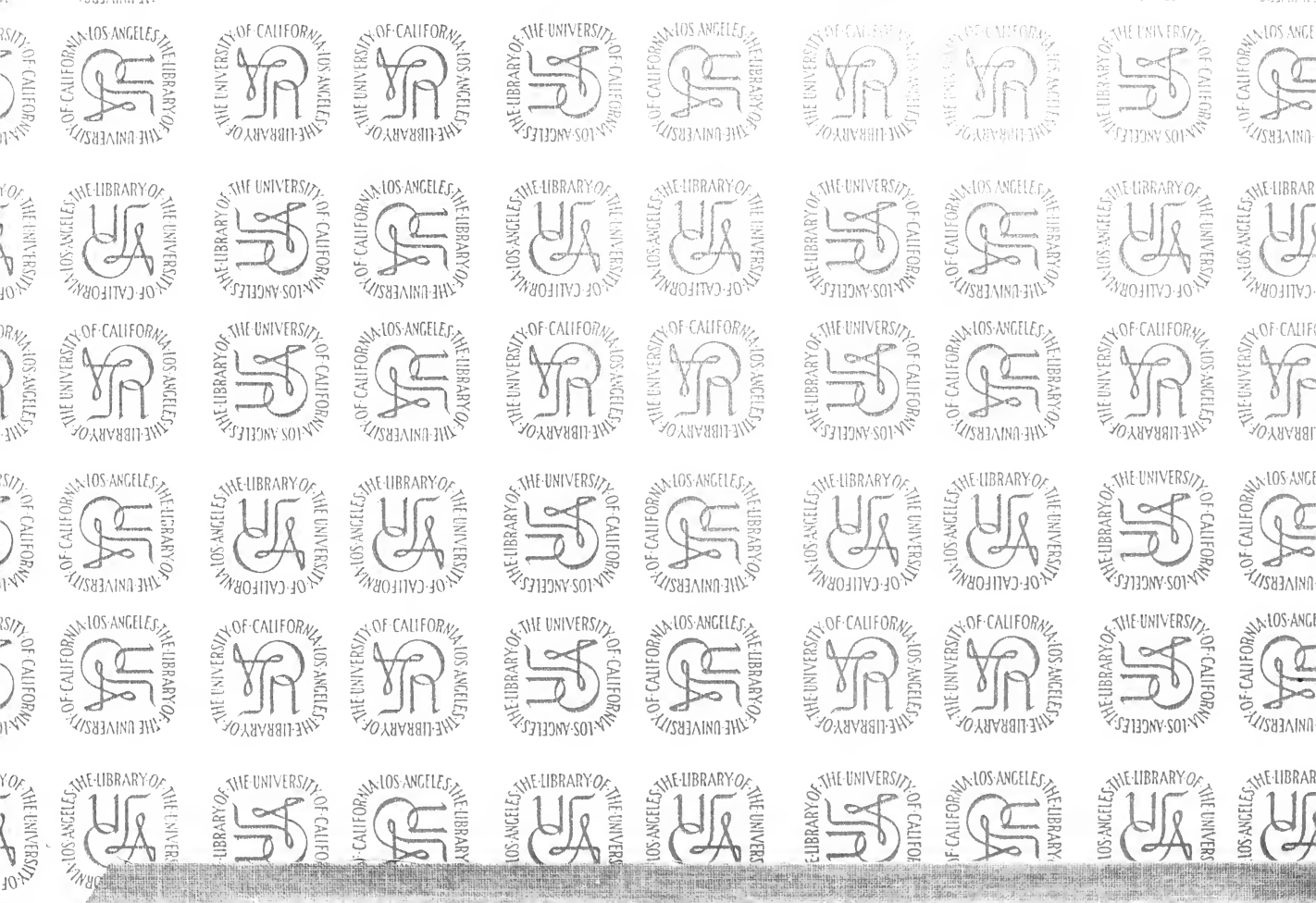
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"The most perfect system of rules to insure success must be interpreted upon the broad grounds of professional intelligence and common sense."

GENERAL SPECIFICATIONS

FOR

STEEL HIGHWAY BRIDGES

AND VIADUCTS.

NEW AND REVISED EDITION,

1896.

By THEODORE COOPER,

Consulting Engineer.

General Specifications for Steel Highway Bridges and Viaducts.

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GENERAL DESCRIPTION.

Highway bridges under these specifications are divided into five classes, for different localities and various loadings, as follows: (§ 28.)

Class A1. City bridges having buckle-plate floors and an accepted form of paving resting on a concrete base. (§§ 8, 9, 10, 59, 60, 61, 62.) Classes.

Class A2. City bridges having plank flooring.

Class B1. Suburban bridges or bridges carrying heavy electric cars.

Class B2. Town or country bridges carrying light electric cars or bridges carrying heavy loads from quarries or manufactories.

Class C. Country bridges carrying only ordinary highway traffic.

1. All parts of the structures shall be of steel, except the flooring, floor joists and wheel guards, when wooden floors are used. Cast-iron or cast-steel may be used in the machinery of movable bridges, for wheel guards, and in special cases for bed-plates.

2. For all through bridges there shall be a clear head-room of 14 feet above the floor. Head-room.

3. Unless otherwise specified, the roadways will be 12 feet wide in the clear for single track and multiples of 10 feet for a greater number of tracks.

4. Where footwalks are required, they will generally be placed outside of the trusses and supported on longitudinal beams resting on overhanging steel brackets.

5. A strong and suitable handrailing will be placed at each side of the bridge and be rigidly attached to the superstructure.

Floor Girders.

6. All cross floor beams will be of rolled or riveted steel girders, rigidly connected to the trusses at the panel points.

7. All longitudinal girders of bridges of Classes A1 and A2 will be of steel; all *track* stringers of bridges of Classes B1 and B2 will be of steel. Unless otherwise specified all other longitudinal girders of Classes B1 and B2 will be of steel. The longitudinal girders of bridges of Class C may be either of wood or steel.

Buckle Plates.

8. Buckle plates will be not less than $\frac{5}{16}$ inch thick and will crown 2 inches at the centre. Plates of this thickness and crown may be used to widths of 4 feet under the roadway and 5 feet under the footwalks.

9. Bridges with buckle-plate floors will have a suitable metal curb on each side of the roadway to hold paving and act as a wheel guard. The wheel guard must be so arranged that it can be removed and replaced when worn or injured. There will also be a metal edging strip on each side of the footwalks to protect and hold the paving in place.

10. Provision must be made at the curbs for drainage clear of all parts of the trusses or floor girders.

Wooden Floor.

11. Wooden floor joists will be spaced not over 2 feet centres, and will lap by each other, so as to have a full bearing on the floor beams, and will be separated $\frac{1}{2}$ inch for free circulation of air. Their scantling will vary in accordance with the length of panels selected, but shall never be less than 3 inches wide.

12. The floor plank shall be inches thick, laid with $\frac{1}{4}$-inch openings, and spiked to each supporting joist. When this is to be covered with an additional wearing floor (§ 13),

it must be laid diagonally and with ½-inch openings; all plank shall be laid with the heart side down.

13. Where specified an additional wearing floor 1½ inches thick of white oak plank shall be placed over the above. (§ 12.)

14. The footwalk plank will be 2 inches thick and not over 6 inches wide, spaced with ⅝-inch openings. Footwalks.

15. There will be a wheel guard, of a scantling not less than 6 x 6, on each side of the roadway to prevent the hubs of wheels striking any part of the bridge.

16. The maximum strain allowed upon the extreme fibre of the joist will be 1,200 pounds per square inch on yellow pine and white oak, and 1,000 pounds per square inch on white pine and spruce. Allowed Strain on Timber.

17. When the longitudinal beams are of steel, they must be securely fastened to the cross floor beams. The floor plank must have a thickness, *in inches*, at least equal to the distance apart of these beams, *in feet*. The floor plank must bear firmly upon the beams and be securely fastened to the same. Steel Beams.

18. Unless otherwise specified, the form of bridge trusses may be selected by the bidder; for through bridges, the end vertical suspenders and two panels of the lower chord, at each end, will preferably be made rigid members. Form of Trusses.

19. Preference will in all cases be given to those designs using stiff lateral and portal bracing of angles and shapes, and to those designs having the least possible number of adjustable members. Rigid Bracing.

20. Each trestle bent shall, as a general rule, be composed of two supporting columns, and the bents united in pairs to form towers; each tower thus formed of four columns shall be thoroughly braced in both directions, and have struts between the feet of the columns. Transversely the columns shall have a batter of not less than one horizontal to six vertical. The feet of the columns must be secured to an anchorage capable of resisting double any possible uplifting. (§ 30.) Trestle Towers.

21. Each tower shall have sufficient base, longitudinally,

to be stable when standing alone, without other support than its anchorage. (§ 30.)

Trestle Spans. 22. Tower spans for high trestles shall not be less than 30 feet.

Length of Span. 23. In calculating strains, the lengths of span shall be understood to be the distance between centres of end pins for trusses, and between centres of bearing plates for all beams and girders.

Proposals. 24. In comparing different proposals, the relative cost of the required masonry or changes in existing work will be taken into consideration.

25. Contractors in submitting proposals shall furnish complete strain sheets, general plans of the proposed structures, and such detail drawings as will clearly show the dimensions of all the parts, modes of construction and the sectional areas.

26. Upon the acceptance of the proposal and the execution of contract, all working drawings required by the Engineer must be furnished free of cost.

Approval of Plans. 27. No work shall be commenced or materials ordered until the working drawings are approved by the Engineer in writing; if such working drawings are detained more than one week for examination, the Contractor will be allowed an equivalent extension of time.

LOADS.

28. All the structures shall be proportioned to carry the following loads:

1st. The weight of metal in the structure.

2d. The weight of the paving and concrete or the wooden floor, considering each foot of board measure to weigh 4 pounds for oak and other hard woods, and 3 pounds for all other kinds.

Dead Load. These two items, taken together, shall constitute "the dead load."

Live Loads. 3d. A "live" or moving load, according to one of the following classes:

CLASS A1 AND CLASS A2.—*City Bridges.*

For the floor and its supports, a load of 100 pounds per square foot of surface of the roadway and footwalks or a concentrated load of 20 tons on two axles 12 feet centres, on any part of the roadway.

For the trusses, a load of 100 pounds per square foot of total floor surface for all spans up to 100 feet; and 80 pounds for all spans over 200 feet; proportionally for intermediate spans.

No span, however, shall be proportioned for a less live load than 2,000 pounds per lineal foot.

CLASS B1.—*Suburban or Interurban Bridges.*

For the floor and its supports, a load of 100 pounds per square foot of total floor surface or 12 tons on two axles $7\frac{1}{2}$ feet centres.

For the trusses, a load of 80 pounds per square foot of total floor surface for all spans up to 100 feet; and 60 pounds for all spans over 200 feet; proportionally for all intermediate spans.

No span, however, shall be proportioned for a less live load than 1,600 pounds per lineal foot.

CLASS B2.—Same as Class B1, excepting concentrated floor load will be 8 tons on two axles 7 feet centres.

CLASS C.—*Country Highway Bridges.*

For the floor and its supports, a load of 80 pounds per square foot of total floor surface or 5 tons on two axles 8 feet centres.

For the trusses, a load of 80 pounds per square foot of total floor surface for all spans up to 75 feet; and 50 pounds for all spans over 200 feet; proportionally for intermediate spans.

No span, however, shall be proportioned for a less live load than 1,200 pounds per lineal foot.

The maximum strains due to all positions of either of the above "live loads," and of the "dead load," shall be taken to proportion all the parts of the structure.

Wind Bracing. 29. To provide for wind strains and vibrations, the top lateral bracing in deck bridges, and the bottom lateral bracing in through bridges, for all spans up to 300 feet, shall be proportioned to resist a lateral force of 300 pounds for each foot of the span; 150 pounds of this to be treated as a moving load.

The bottom lateral bracing in deck bridges, and the top lateral bracing in through bridges for all spans up to 300 feet, shall be proportioned to resist a lateral force of 150 pounds for each foot of the span.

For spans exceeding 300 feet, add, in each of the above cases, 10 pounds for each additional 30 feet of span. (Art. 60.)

30. In trestle towers the bracing and columns shall be proportioned to resist the following lateral pressures, in addition to the strains from dead and live load:

The trusses loaded or unloaded, the lateral pressures specified above; and a lateral pressure of 100 pounds for each vertical lineal foot of the trestle bents.

Temperature. 31. Variations in temperature, to the extent of 150 degrees, shall be provided for.

32. All parts shall be so designed that the strains coming upon them can be accurately calculated.

PROPORTION OF PARTS.

Tensile Strain. 33. All parts of the structures shall be proportioned in tension by the following allowed unit strains:

For Medium Steel.

	Pounds per square inch.
Medium Steel. On longitudinal, lateral and sway bracing, for wind and live load strains	18,000
On solid rolled beams, used as cross floor beams and stringers (Art. 46)	13,000

	Pounds per square inch.
On bottom flange of riveted girders, net section (Art. 44)	13,000
On floor beam hangers, and other similar members liable to sudden loading (bars with forged ends)	9,000
On floor beam hangers, and other similar members liable to sudden loading (plates or shapes), net section	8,000

	For live loads.	For dead loads.
Bottom chords, main diagonals, counters and long verticals (forged eye-bars)	12,500	25,000
Bottom chords and flanges, main diagonals, counters and long verticals (plates or shapes), net section	11,000	22,000

For swing bridges and other movable structures, the dead load unit strains, during motion, must not exceed three-fourths of the above allowed unit strains for dead load on stationary structures.

The areas obtained by dividing the live load strains by the live load unit strains will be added to the areas obtained by dividing the dead load strains by the dead load unit strains to determine the required sectional area of any member.

Soft steel may be used in tension with unit strains ten per cent. less than those allowed for *medium steel.* Soft Steel.

34. Single angles subject to direct tension must be connected by both legs, or the section of one leg only will be considered as effective.

35. In members subject to tensile strains full allowance shall be made for reduction of section by rivet-holes, screw-threads, etc. Net Section.

36. Compression members shall be proportioned by the following allowed unit strains: Compressive Strains.

For Medium Steel.

Medium Steel. Chord segments $P=12{,}000-55\frac{l}{r}$ for live load strains.

$P=24{,}000-110\frac{l}{r}$ for dead load strains.

All posts of through bridges. $P=10{,}000-45\frac{l}{r}$ for live load strains.

$P=20{,}000-90\frac{l}{r}$ for dead load strains.

All posts of deck bridges and trestles. $P=11{,}000-50\frac{l}{r}$ for live load strains.

$P=22{,}000-100\frac{l}{r}$ for dead load strains.

End posts are not to be considered chord segments.

Lateral struts and rigid bracing. $P=13{,}000-70\frac{l}{r}$ for wind strains;

for live load strains use two-thirds of the above.

Lateral struts, with adjustable bracing, will be proportioned by the above formula to resist the maximum due either to the wind and load or to an assumed initial strain of 10,000 pounds per square inch on all the rods attached to them. (§ 42.)

P=the allowed strain in compression per square inch of cross-section, in pounds.

l=the length of compression member, in inches.

r=the least radius of gyration of the section, in inches.

No compression member, however, shall have a length exceeding 125 times its least radius of gyration.

Soft Steel. *Soft steel* may be used in compression with unit strains fifteen per cent. less than those allowed for *medium steel.*

For swing bridges and other movable structures, the dead load unit strains during motion must not exceed $\frac{3}{4}$ of the above allowed unit strains for dead load on stationary structures.

37. For long span bridges, when the ratio of the length and width of span is such that it makes the top chord acting as a whole, a longer column than the segments of the chord, the chord will be proportioned for this greater length.

Alternate Strains.

38. Members subject to alternate strains of tension and compression shall be proportioned to resist each kind of strain. Both of the strains shall, however, be considered as increased by an amount equal to $\frac{8}{10}$ of the least of the two strains, for determining the sectional areas by the above allowed unit strains. (§§ 33, 36.)

Effect of Wind.

39. The strains in the truss members or trestle posts from the assumed wind forces need not be considered except as follows:

1st. When the wind strains on any member exceed one-quarter of the maximum strains due to the dead and live loads upon the same member. The section shall then be increased until the total strain per square inch will not exceed by more than one-quarter the maximum fixed for dead and live loads only.

2d. When the wind strain alone or in combination with a possible temperature strain, can neutralize or reverse the strains in any member.

Rivets, Bolts and Pins.

40. The rivets in all members, other than those of the floor and lateral systems, must be so spaced that the shearing strain per square inch shall not exceed 10,000 pounds; nor the pressure on the bearing surface, (diameter $\times$ thickness of the piece), of the rivet-hole exceed 16,500 pounds per square inch.

The rivets in all members of the floor system, including all hanger connections, must be so spaced that the shearing strains and bearing pressures shall not exceed 80 per cent. of the above limits.

The rivets in the lateral and sway bracing will be allowed 40 per cent. increase upon the above limits.

In the case of field riveting (and for bolts as per § 58) the above-allowed shearing strains and pressures shall be reduced one-third.

Rivets and bolts must not be used in direct tension.

41. Pins shall be proportioned so that the shearing strain shall not exceed 10,000 pounds per square inch; nor the crushing strain on the projected area of the semi-intrados of any member (other than forged eye-bars, see § 84) connected to the pin be greater per square inch than 18,000 pounds; nor the bending strain exceed 20,000 pounds, when the applied forces are considered as uniformly distributed over the middle half of the bearing of each member.

Combined Strains.

42. When any member is subjected to the action of both axial and bending strains, as in the case of end posts of through bridges (§ 39), or of chords carrying distributed floor loads, it must be proportioned so that the greatest fibre strain will not exceed the allowed limits of tension or compression on that member.

If the fibre strain resulting from the weight only, of any member, exceeds ten per cent. of the allowed unit strain on such member, such excess must be considered in proportioning the areas.

Compression Flanges.

43. In beams and plate girders the compression flanges shall be made of the same *gross* section as the tension flanges.

Plate Girders, etc.

44. Plate girders shall be proportioned upon the supposition that the bending or chord strains are resisted entirely by the upper and lower flanges, and that the shearing or web strains are resisted entirely by the web-plate; no part of the web-plate shall be estimated as flange area.

The distance between centres of gravity of the flange areas will be considered as the effective depth of all girders.

Web Plates.

45. The webs of plate girders must be stiffened at intervals, about the depth of the girders, wherever the shearing strain per square inch exceeds the strain allowed by the following formula:

$$\text{Allowed shearing strain} = \frac{15{,}000}{1 + \frac{H^2}{3{,}000}}$$

where H = ratio of depth of web to its thickness; but no

web-plates shall be less than one-quarter of an inch in thickness.

46. Rolled beams shall be proportioned (§§ 33, 43) by their moments of inertia. Rolled Beams.

DETAILS OF CONSTRUCTION.

47. All the connections and details of the several parts of the structures shall be of such strength that, upon testing, rupture will occur in the body of the members rather than in any of their details or connections. Details.

48. Preference will be had for such details as shall be most accessible for inspection, cleaning and painting; no closed sections will be allowed.

49. The pitch of rivets in all classes of work shall never exceed 6 inches, or sixteen times the thinnest outside plate, nor be less than three diameters of the rivet. Riveting.

50. The rivets used shall generally be $\frac{5}{8}$, $\frac{3}{4}$ and $\frac{7}{8}$ inch diameter.

51. The distance between the edge of any piece and the centre of a rivet-hole must never be less than $1\frac{1}{4}$ inches, except for bars less than $2\frac{1}{2}$ inches wide; when practicable it shall be at least two diameters of the rivet.

52. For punching, the diameter of the die shall in no case exceed the diameter of the punch by more than $\frac{1}{16}$ of an inch, and all holes must be clean cuts without torn or ragged edges.

53. All rivet holes must be so accurately spaced and punched that when the several parts forming one member are assembled together, a rivet $\frac{1}{16}$ inch less in diameter than the hole can generally be entered, hot, into any hole, without reaming or straining the metal by "drifts"; occasional variations must be corrected by reaming.

54. The rivets when driven must completely fill the holes. The rivet-heads must be round and of a uniform size for the same sized rivets throughout the work. They must be full and neatly made, and be concentric to the rivet-hole, and thoroughly pinch the connected pieces together.

55. Wherever possible, all rivets must be machine driven. The machines must be capable of retaining the applied pressure after the upsetting is completed. No hand-driven rivets exceeding $\frac{7}{8}$ inch diameter will be allowed.

56. Field riveting must be reduced to a minimum or entirely avoided, where possible.

Net Sections.

57. The effective diameter of a driven rivet will be assumed the same as its diameter before driving. In deducting the rivet-holes to obtain net sections in tension members, the diameter of the rivet-holes will be assumed as $\frac{1}{8}$ inch larger than the undriven rivets.

The rupture of a riveted tension member is to be considered as equally probable, either through a transverse line of rivet-holes or through a diagonal line of rivet-holes, where the net section does not exceed by 30 per cent. the net section along the transverse line.

The number of rivet-holes to be deducted for net section will be determined by this condition.

Bolts.

58. When members are connected by bolts the holes must be reamed parallel and the bolts turned to a driving fit. All bolts must be of neat lengths, and shall have a washer under the heads and nuts where in contact with wood. Bolts must not be used in place of rivets, except by special permission.

Buckle plates.

59. Buckle plates must be firmly riveted to the supporting beams and be spliced at all free edges. Preferably they will be made in continuous sheets of panel lengths. They may be pressed or formed without heating.

60. A buckle-plate floor, as specified, may be considered as the required lateral system of bracing at the floor level.

61. The buckle plates of the sidewalks will be covered to the proper slope and level for the wearing pavement with bitumen concrete of an accepted and waterproof character.

62. The buckle plates of the roadway will be covered with an acceptable and waterproof concrete (bitumen or cement) to the proper crown and grade for the wearing pavement, but at no place must the concrete be less than 3 inches thick.

63. The several pieces forming one built member must fit closely together, and when riveted shall be free from twists, bends or open joints.

64. All joints in riveted tension members must be fully and symmetrically spliced. Splices.

65. In compression members, abutting joints with planed faces must be sufficiently spliced to maintain the parts accurately in contact against all tendencies to displacement. Abutting Joints.

66. In compression members, abutting joints with untooled faces must be fully spliced, as no reliance will be placed on such abutting joints. The abutting ends must, however, be dressed straight and true, so there will be no open joints.

67. The webs of plate girders must be spliced at all joints by a plate on each side of the web. Web Splices.

68. All web-plates must have stiffeners over bearing points and at points of local concentrated loadings; such stiffeners must be fitted at their ends to the flange angles, at the bearing points. Stiffeners.

69. All other angles, filling and splice plates on the webs of girders and riveted members must fit at their ends to the flange angles, sufficiently close to be sealed, when painted, against admission of water.

70. Web-plates of all girders must be arranged so as not to project beyond the faces of the flange angles, nor on the top be more than $\frac{1}{16}$ inch below the face of these angles, at any point. Web-Plates.

71. Wherever there is a tendency for water to collect, the spaces must be filled with a suitable waterproof material.

72. In girders with flange plates, at least one-half of the flange section shall be angles or else the largest sized angles must be used. Flange Plates.

73. In lattice girders and trusses the web members must be double and connect symmetrically to the webs of the chords. The use of plates or flats, alone, for tension members must be avoided, where it is possible; in lattice trusses, the counters, suspenders and two panels of the lower chord, at each end, must be latticed as for compression members. (See Arts. 89, 90 and 91.) Lattice girders.

Flanges of girders.

74. The compression flanges of beams and girders shall be stayed against transverse crippling when their length is more than twenty times their width.

75. The unsupported width of plates subjected to compression shall not exceed thirty times their thickness; except cover plates of top chords and end posts, which will be limited to forty times their thickness.

76. The flange plates of all girders must be limited in width so as not to extend beyond the outer lines of rivets connecting them with the angles, more than five inches or more than eight times the thickness of the first plate. Where two or more plates are used on the flanges, they shall either be of equal thickness or shall decrease in thickness outward from the angles.

Limiting thickness.

77. No metal shall be used less than $\frac{1}{4}$ inch thick, except for lining or filling vacant spaces.

Eye-Bars.

78. The heads of eye-bars shall be so proportioned and made, that the bars will preferably break in the body of the original bar rather than at any part of the head or neck. The form of the head and the mode of manufacture shall be subject to the approval of the Engineer. (Art. 137.)

79. The bars must be free from flaws and of full thickness in the necks. They shall be perfectly straight before boring. The holes shall be in the centre of the head, and on the centre line of the bar.

80. The bars must be bored to lengths not varying from the calculated lengths more than $\frac{1}{64}$ of an inch for each 25 feet of total length.

81. Bars which are to be placed side by side in the structure shall be bored at the same temperature and of such equal length that upon being piled on each other the pins shall pass through the holes at both ends without driving.

82. The lower chord shall be packed as narrow as possible.

Pins.

83. The pins shall be turned straight and smooth; chord pins shall fit the pin-holes within $\frac{1}{50}$ of an inch, for pins less than $4\frac{1}{2}$ inches diameter; for pins of a larger diameter the clearance may be $\frac{1}{32}$ inch. Lateral pins shall fit the pin-holes within $\frac{1}{16}$ of an inch.

84. The diameter of the pin shall not be less than three-quarters the largest dimension of any eye-bar attached to it. The several members attaching to the pin shall be so packed as to produce the least bending moment upon the pin, and all vacant spaces must be filled with wrought filling rings.

85. All rods with screw ends shall be upset at the ends, so that the diameter at the bottom of the threads shall be $\frac{1}{16}$ inch larger than any part of the body of the bar. Upset Ends.

86. All threads must be of the United States standard, except at the ends of the pins.

87. Floor beam hangers shall be made without adjustment and so placed that they can be readily examined at all times. Hangers.

88. All the floor beams must be effectually stayed against end motion or any tendency to rotate from the action of the lateral system.

89. Compression members shall be of steel, and of approved forms. Compression Members.

90. The pitch of rivets at the ends of compression members shall not exceed four diameters of the rivets for a length equal to twice the width of the member.

91. The open sides of all compression members shall be stayed by batten plates at the ends and diagonal lattice-work at intermediate points. The batten plates must be placed as near the ends as practicable, and shall have a length not less than the greatest width of the member or $1\frac{1}{2}$ times its least width. The size and spacing of the lattice bars shall be duly proportioned to the size of the member. They must not be less than $1\frac{1}{2} \times \frac{1}{4}$ inches for 5 to 6 inch channels; $1\frac{3}{4} \times \frac{1}{4}$ inches for 7 to 8 inch channels; $2 \times \frac{5}{16}$ inches for 9 to 12 inch channels; $2\frac{1}{4} \times \frac{8}{8}$ inches for 13 to 16 inch channels; $2\frac{1}{2} \times \frac{7}{16}$ inches for 17 to 20 inch channels; $2\frac{1}{2} \times \frac{1}{2}$ inches for 21 and upwards inch channels. They shall be inclined at an angle not less than 60° to the axis of the member for single latticing, nor less than 45° for double latticing with riveted intersections. The pitch of the latticing must not exceed the width of the channel plus nine inches.

92. Where necessary, pin-holes shall be reinforced by

plates, some of which must be of the full width of the member, so the allowed pressure on the pins shall not be exceeded, and so the strains shall be properly distributed over the full cross section of the members. These reinforcing plates must contain enough rivets to transfer their proportion of the bearing pressure, and at least one plate on each side shall extend not less than six inches beyond the edge of the batten plates. (§ 91.)

93. Where the ends of compression members are forked to connect to the pins, the aggregate compressive strength of these forked ends must equal the compressive strength of the body of the members.

94. In compression chord sections, the material must mostly be concentrated at the sides, in the angles and vertical webs. Not more than one plate, and this not exceeding $\frac{3}{8}$ inch in thickness, shall be used as a cover plate, except when necessary to resist bending strains, or to comply with § 75. (§ 42).

95. The ends of all square-ended members shall be planed smooth, and exactly square to the centre line of strain.

96. All members must be free from twists or bends. Portions exposed to view shall be neatly finished.

97. Pin-holes shall be bored exactly perpendicular to a vertical plane passing through the centre line of each member, when placed in a position similar to that it is to occupy in the finished structure.

Lateral Bracing.

98. Where rods are used in the lateral, longitudinal or sway bracing (§ 19), they shall be square bars, but in no case shall they have a less area than $\frac{3}{4}$ of a square inch. Rods with bent eyes must not be used.

Transverse Diagonal Bracing.

99. All through bridges shall have latticed portals, of approved design, at each end of the span, connected rigidly to the end posts and top chords. They shall be as deep as the specified head-room will allow. (§ 2.) (§ 91.)

100. Knee braces shall be placed at each intermediate panel point, and connected to the vertical posts and top lateral struts, for trusses 20 feet and less in depth.

100½. When the height of the trusses exceeds 20 feet, an approved system of overhead diagonal bracings shall be attached to each post at an elevation sufficient to give the required head-room (§ 2) and to the top lateral struts.

101. All bars and rods in the web, lateral, longitudinal or sway systems must be securely clamped at their intersections to prevent sagging and rattling.

102. Pony trusses and through plate or lattice girders shall be stayed by knee braces or gusset plates attached to the top chords at the ends and at intermediate points, and attached below to the cross floor beams or to the transverse struts.

103. All deck girders shall have transverse braces at the ends. All deck bridges shall have transverse bracing at each panel point. This bracing shall be proportioned to resist the unequal loading of the trusses.

104. All bridges must have lateral struts at the ends, except where end floor beams act as such.

Bed-Plates.

105. All bed-plates must be of such dimensions that the greatest pressure upon the masonry shall not exceed 250 pounds per square inch.

Friction Rollers.

106. All bridges over 75 feet span shall have at one end nests of turned friction rollers running between planed surfaces. These rollers shall not be less than 2⅞ inches diameter for spans 100 feet or less, and for greater spans this diameter shall be increased in proportion of 1 inch for 100 feet additional.

The rollers shall be so proportioned that the pressure per lineal inch of roller shall not exceed the product of the diameter in inches by 300 pounds (300d.).

The rollers must be of machinery steel and the bearing plates of medium steel.

The rollers and bearings must be so arranged that they can be readily cleaned and so that they will not hold water.

107. Bridges less than 75 feet span shall be secured at one end to the masonry, and the other end shall be free to move longitudinally upon planed surfaces.

108. Where two spans rest upon the same masonry, a continuous plate, not less than ⅝ inch thick, shall extend under

the two adjacent bearings, or the two bearings must be rigidly tied together.

Pedestals and Bed-Plates

109. Pedestals shall be made of riveted plates and angles. All bearing surfaces of the base plates and vertical webs must be planed. The vertical webs must be secured to the base by angles having two rows of rivets in the vertical legs. No base plate or web connecting angle shall be less in thickness than $\frac{1}{2}$ inch. The vertical webs shall be of sufficient height and must contain material and rivets enough to practically distribute the loads over the bearings or rollers.

Where the size of the pedestal permits, the vertical webs must be rigidly connected transversely.

110. All the bed-plates and bearings under fixed and movable ends must be fox-bolted to the masonry; for trusses, these bolts must not be less than $1\frac{1}{4}$ inches diameter; for plate and other girders, not less than $\frac{7}{8}$ inch diameter. The contractor must furnish all bolts, drill all holes and set bolts to place with sulphur or Portland cement.

111. While the roller ends of all trusses must be free to move longitudinally under changes of temperature, they shall be anchored against lifting or moving sideways.

Camber.

112. All bridges shall be cambered by giving the panels of the top chord an excess of length in the proportion of $\frac{3}{16}$ of an inch to every ten feet.

Trestle Towers.

113. The lower struts in trestle towers must be capable of resisting the strains due to changes of temperature or of moving the tower pedestals under the effects of expansion or contraction.

For high or massive towers, these lower struts will be securely anchored to intermediate masonry piers, or the tower pedestals will have suitably placed friction rollers, as may be directed by the Engineer.

114. All joints in the tower columns shall be fully spliced for all possible tension strains, and to hold the parts firmly in position.

Tower Bed-Plates.

115. Tower footings and bed-plates must be planed on all bearing surfaces; and the holes for anchor bolts slotted to allow for the proper amount of movement. (§ 31.)

116. All workmanship shall be first-class in every particular. Workmanship.

117. All eye-bars must be made of medium steel.

118. Eye-bars, all forgings and any pieces which have been partially heated or bent cold must be wholly annealed. Crimped stiffeners and buckle plates need not be annealed. Treatment of steel.

119. No reliance will be placed upon the welding of steel.

120. No sharp or unfilleted angles or corners will be allowed in any piece of metal.

121. Riveted work of medium steel will be subject to the following conditions:

All sheared edges of plates and angles will be planed off to a depth of $\frac{1}{4}$ of an inch and all punched holes will be reamed to a diameter $\frac{1}{8}$ of an inch larger so as to remove all the sheared surface of the metal; unless the material is such that any rivet holes punched as in ordinary practice (§§ 50, 51, 52) will stand drifting to a diameter one-third greater than the original holes, without cracking either in the periphery of the holes or on the external edges of the piece, whether they be sheared or rolled.

Medium steel may be used in compression in chords, posts, flanges and bearing plates without reaming for any thicknesses of metal which will stand the above drifting test. Medium steel may be used in tension without reaming up to a thickness of $\frac{9}{16}$ of an inch, if the metal of this thickness will stand the above drifting test and the adjacent edges of the pieces be rolled or planed off, as above required.

122. Soft steel need not be reamed, if it satisfies the above drifting test. (121.)

123. All parts of any tension or compression flange or member, must be of the same kind of steel, but webs of plate girders and the tension members of all girders, plate or lattice, may be made of soft steel in connection with compression members of medium steel.

124. All splices must be of the same kind of steel as the parts to be joined.

125. Pilot nuts must be used during the erection to protect the threads of the pins. Pilot nuts.

QUALITY OF MATERIAL.

STEEL.

General requirements.

126. The steel must be uniform in character for each specified kind. The finished bars, plates and shapes must be free from cracks on the faces or corners, and have a clean, smooth finish. No work shall be put upon any steel at or near the blue temperature or between that of boiling water and of ignition of hard wood sawdust.

127. All tests shall be made on samples cut from the finished material after rolling. The samples to be at least 12 inches long, and to have a uniform sectional area not less than $\frac{1}{2}$ square inch.

128. Material which is to be used without annealing or further treatment is to be tested in the condition in which it comes from the rolls. When material is to be annealed or otherwise treated before use, the specimen representing such material is to be similarly treated before testing.

The elongation shall be measured on an original length of 8 inches. Two test pieces shall be taken from each melt or blow of finished material, one for tension and one for bending. (Art. 142.)

129. All samples or full-sized pieces must show uniform fine grained fractures of a blue steel-gray color, entirely free from fiery lustre or a blackish cast.

Medium Steel.

130. **Medium Steel** shall have an ultimate strength, when tested in samples of the dimensions above stated, of 60,000 to 68,000 pounds per square inch, an elastic limit of not less than one-half of the ultimate strength, and a minimum elongation of 22 per cent. in 8 inches. Steel for pins may have a minimum elongation of 15 per cent.

131. Before or after heating to a low cherry red and cooling in water at 82 degrees Fah., this steel must stand bending to a curve whose inner radius is one and a half times the thickness of the sample, without cracking.

Soft Steel.

132. **Soft Steel** shall have an ultimate strength, on same sized samples, of 54,000 to 62,000 pounds per square inch, an elastic limit not less than one-half the ultimate strength, and a minimum elongation of 25 per cent. in 8 inches.

133. Before or after heating to a light yellow heat and quenching in cold water, this steel must stand bending 180 degrees, to a curve whose inner radius is equal to the thickness of the sample, without sign of fracture.

134. Rivet steel shall have an ultimate strength of 50,000 to 58,000 pounds per square inch and an elongation of 26 per cent.

135. The steel for rivets must, under the above bending test (133), stand closing solidly together without sign of fracture.

136. Eye-bar material, $1\frac{1}{2}$ inches and less in thickness, shall, on test pieces cut from finished material, fill the above requirements. For thicknesses greater than $1\frac{1}{2}$ inches, there will be allowed a reduction in the percentage of elongation of 1 per cent. for each $\frac{1}{8}$ of an inch increase of thickness, to a minimum of 20 per cent. (Art. 117.) Eye-bars.

137. Full sized eye-bars shall show not less than 10 per cent. elongation in the body of the bar, and an ultimate strength not less than 56,000 pounds per square inch. Should a bar break in the head, but develop 10 per cent. elongation and the ultimate strength specified, it shall not be cause for rejection, provided not more than one-third of the total number of bars tested break in the head.

138. A variation of cross-section or weight in the finished members of $2\frac{1}{2}$ per cent. from the specified size may be cause for rejection.

Steel Castings.

139. Steel castings will be used for drawbridge wheels, track segments and gearing. (Art. 1.) Steel Castings.

They must be true to form and dimensions, of a workmanlike finish and free from injurious blowholes and defects.

When tested in specimens of uniform sectional area of at least $\frac{1}{2}$ square inch for a distance of 2 inches, they must show an ultimate strength of not less than 67,000 pounds per square inch, an elastic limit of one-half the ultimate, and an elongation in 2 inches of not less than 10 per cent.

The metal must be uniform in character, free from hard or soft spots, and capable of being properly tool finished.

Cast Iron.

Cast Iron.

140. Except where chilled iron is required, all castings must be of tough, gray iron, free from cold shuts or injurious blowholes, true to form and thickness, and of a workmanlike finish. Sample pieces, 1 inch square, cast from the same heat of metal in sand moulds, shall be capable of sustaining, on a clear span of 12 inches, a central load of 2,400 pounds, when tested in the rough bar. A blow from a hammer shall produce an indentation on a rectangular edge of the casting without flaking the metal.

Timber.

Timber.

141. The timber, unless otherwise specified, shall be strictly first-class southern yellow pine or white oak bridge timber, sawed true, and out of wind, full size, free from wind shakes, large or loose knots, decayed or sap wood, worm holes, or other defects impairing its strength or durability. It will be subject to the inspection and acceptance of the Engineer.

INSPECTION.

Inspection.

142. All facilities for inspection of the materials and workmanship shall be furnished by the contractor. He shall furnish without charge such specimens (prepared) of the several kinds of steel to be used, as may be required to determine their character.

Testing.

143. The contractor must furnish the use of a testing machine capable of testing the above specimens at all mills where the steel may be manufactured, free of cost.

144. Full sized parts of the structure may be tested at the option of the Engineer, but if tested to destruction, such material shall be paid for at cost, less its scrap value to the contractor, if it proves satisfactory. If it does not stand the specified tests, it will be considered rejected material, and be solely at the cost of the contractor.

PAINTING.

145. All iron work before leaving the shop shall be thoroughly cleaned from all loose scale and rust, and be given one good coating of pure raw linseed oil, well worked into all joints and open spaces. Painting.

Buckle plates shall be given a thick and thorough coating of red lead and linseed oil before shipment. All rivet heads in the buckle-plate floor shall also be coated with this red lead paint as soon as practicable after they are driven.

146. In riveted work the surfaces coming in contact shall each be painted before being riveted together. Bottoms of bed-plates, bearing-plates, and any parts which are not accessible for painting after erection, shall have two coats of paint; the paint shall be a good quality of iron ore paint, mixed with pure linseed oil, unless otherwise directed. It will be subject to approval of the Engineer.

147. After the structure is erected, the metal work shall be thoroughly and evenly painted with two additional coats of paint, mixed with pure linseed oil. All recesses which will retain water, or through which water can enter, must be filled with thick paint or some waterproof cement before receiving the final painting.

148. Pins, bored pin-holes and turned friction rollers shall be coated with white lead and tallow before being shipped from the shop.

ERECTION.

149. The contractor, unless it be otherwise specified, shall furnish all staging and false work, shall erect and adjust all the metal work, and put in place all floor timbers, guards, etc., complete. Erection.

150. The contractor shall so conduct all his operations as not to interfere with the work of other contractors, or close any thoroughfare by land or water.

151. The contractor shall assume all risks of accidents to men or material prior to the acceptance of the finished structure.

The contractor must also remove all false work, piling and other obstructions, or unsightly material produced by his operations.

FINAL TEST.

Final Test.

152. Before the final acceptance the Engineer may make a thorough test by passing over each structure the specified loads, or their equivalent, or by resting the maximum load upon the structure for twelve hours.

After such tests the structures must return to their original positions without showing any permanent change in any of their parts.

SUPPLEMENTARY.

The following special clauses shall apply in addition to previous general clauses, to the special work included in the attached contract:

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GENERAL DATA.

For a bridge crossing.....in the town of.....County of.....State of .....to be built according to the general requirements of the accompanying specifications:

Width of roadway.....

Number of footwalks.....

Width of footwalks.....

Height of floor above flood-line.....

Height of floor above ordinary stage of water.....

Depth of river at ordinary stage of water.....

Character of river bed.....

Usual seasons for floods.....

Length of haul from nearest freight station.....

Specified live load, Class A1, A2, B1, B2 or C, paragraph 28, to be adopted for this bridge.....

Sizes of piers (if built or contracted for).....

Skew of piers, or angle of current with line of the bridge..

Total length of bridge.....

Length of spans centre to centre of piers.....